

## **TASK 9. ADULT IN-MIGRATION, 1990-1991**

### **9.1 OBJECTIVE**

The objectives of the chinook salmon in-migration monitoring program at Woodbridge Dam during 1990 and 1991 were to evaluate the benefit of attraction flows; to document the number, size, sex ratio and timing of adult and grilse chinook salmon migrating past Woodbridge Dam; and to determine whether rainfall, barometric pressure, or water temperature influence the timing of chinook salmon migration past Woodbridge Dam. In addition, monitoring systems (a video camera in the fish ladders, a video camera at the dam, and a fish trap) were compared at Woodbridge Dam for determining salmon escapement into the upper river in both years.

### **9.2 METHODS**

#### **9.2.1 Upper Ladder Monitoring**

##### **9.2.1.1 1990**

The upper ladder was monitored with both a video camera and an upstream migrant trap from 2-15 October 1990. This system was replaced with the lower ladder video and trap monitoring system after the flashboards at Woodbridge Dam were removed on 15 October.

Video monitoring equipment was installed in the uppermost chamber of the pool and weir fishway (pool 15) (Figure 9-1). A 1.2 m x 1.2 m piece of marine plywood covered with white plastic served as a background. This board was installed at the entrance to pool 15 approximately 50 cm under the water surface so that salmon could swim over it. Black lines were drawn at intervals of 10 cm on the white surface so that fish lengths could be estimated. Each side of the background was lined with a 0.6 m high plastic net (1.3 cm mesh) to ensure that all fish moved through the center of the background. Four 60-watt, halogen spot lights were mounted above the white background for illumination. A Sony Handycam water-resistant video camera (model CCD SP7) was positioned 1.5 m above the water surface; at this height, a 1.2 m x 1.2 m section of the background could be monitored. Mitsubishi VHS video recorders (model HS U32) were used to record fish movements in the upper ladder.

To monitor all fish moving through the upper fishway and to verify the movement of fish recorded by the video system, an upstream migrant trap was also installed in the upper ladder. This upstream trap was placed in the underground passageway leading from Lake Lodi to the upper ladder (Figure 9-1). The trap was constructed by screening the exit to the chamber and placing a one-way baffle in the entrance (Figure 9-1). This trap was checked three times a day. All trapped salmon were netted and counted and the numbers of males, females, and precocious salmon (grilse) were obtained. Grilse or "jacks" were defined as

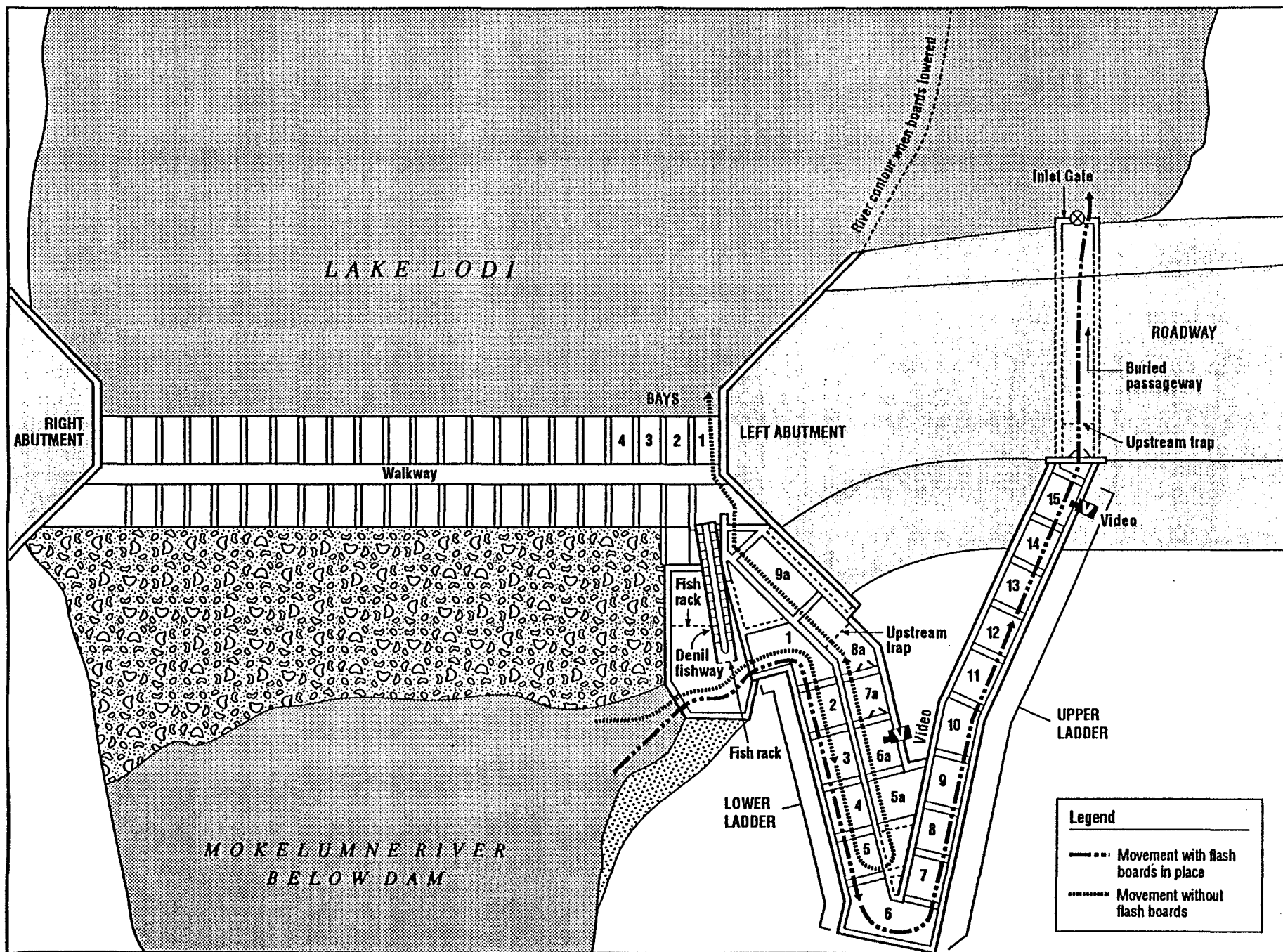


Figure 9-1. Plan view of Woodbridge Dam showing fish ladders, positions of video cameras, upstream traps, and routes taken by salmonids during upmigration.

salmon less than or equal to 60 cm total length (TL). To minimize handling stress, the estimated length and general condition of all fish were visualized.

#### **9.2.1.2 1991**

The upper ladder was monitored by both a video system and upstream migrant trap from 2 - 31 October, 1991. After the boards at Woodbridge Dam were removed on 31 October 1991, the upper ladder system was replaced by a lower ladder video and trap monitoring system.

The systems used in 1991 were similar to those described for 1990, with some differences in setup and equipment. In addition to four 60-watt halogen spot lights attached to the grating above the water, two 750-watt pool lights were mounted below the water surface to provide background illumination. The monitoring system consisted of a Panasonic closed circuit camera (model WV-CL354) equipped with a wide angle lens (model WV-LA4.5) which was positioned 2 m above the white background; at this height, the entire area of the background could be observed. A Panasonic VHS time lapse recorder (model AG-6720A) equipped with a Pelco single channel motion detector (model MD 2000) was used; it was activated by any movement through the field of vision. Detection of movement causes the video recording speed to increase to a high speed recording mode for a period of 30 seconds. The change in recording speed is termed an "alarm signal," which can later be identified on the tape using an alarm search function on the video recorder. A video monitor (model TR 930B) was also installed at the dam to monitor the viewing and recording conditions. The video system was checked and tapes changed approximately every 12 hours from 2 to 31 October 1991.

The upper ladder trap and video systems were monitored concurrently, from 2-31 October 1991 for calibration. A metal screen (2 m high, 2.7 m long) was placed across the underground chamber in 1991, effectively dividing the chamber into two sections, a downstream trapping area and an upstream release area. This screen formed a barrier to all upstream movement and a one-way baffle was installed (1 x 1 m, 5 cm mesh) in the entrance to the chamber, to prevent fish from returning downstream (Figure 9-1). The trap was checked daily from 2 to 31 October 1991.

### **9.2.2 Lower Ladder Monitoring**

#### **9.2.2.1 1990**

In 1990, the lower ladder was monitored with a video and upstream migrant trap system from 15 October, after the dam was lowered, until 17 December. After the flashboards were removed, water was released through dam bays 1 to 4 (Figure 9-1). Salmon movement was restricted to the lower ladder by screening the Denil fishway and dam bays 2 and 3 with a steel frame barrier. Passage through dam bay 4 was blocked by riprap.

The methods and equipment used were similar to those described for the upper ladder in 1990. The video system was installed in chamber 6A (Figure 9-1). At first the white background was placed on the floor of the chamber in front of the entrance, but the water

was so turbid after the boards were removed that the background was raised by 0.6 m on 20 October to improve viewing conditions. This reduced the depth of the water over the background to 35 cm. A metal screen (0.6 m x 1.2 m, 5 cm mesh) was placed in front of the background, which forced the salmon to move up in the water column and over the background. The camera was attached to the metal grating covering this pool, 0.9 m above the water surface. A wide angle lens (Sony VCL 0446) was attached to the camera to view the entire background. The lighting system was similar to the one previously described for 1990. A VCR was used to record data.

The upstream migrant trap was constructed in the lower ladder by placing wire mesh one-way baffles (0.6 m x 0.6 m, 15.2 cm mesh) in the entrance of chamber 8A (Figure 9-1). Pool 8A was further modified into a trap by placing a metal screen (1.5 m x 3.0 m, 5 cm mesh) across the chamber and dividing pool 8A into two sections, a downstream trapping area and an upstream release area (Figure 9-1). Salmon moving upstream through the lower ladder were trapped in pool 8A. Water levels for video and trap monitoring and to supply passage flows in the lower ladder were regulated by an inlet gate in pool 8A.

The trap was checked three times daily at 0700, 1500, and 2300 hrs. The inlet gate from pool 9A (Figure 9-1) was closed to lower the water level in the trap. In accordance with CDFG outlines, the inlet gate from pool 9A was opened at least 30 cm during trap operations to allow released salmon to move upstream.

EBMUD supplied water temperature data monitored downstream of Woodbridge Dam near the Woodbridge Golf Course. Flow data were obtained from the USGS gaging station (#11325500) located downstream of Woodbridge Dam. Precipitation data (recorded at the Lodi Fire Station #3) and barometric pressure data (recorded at Sacramento Executive Airport) was obtained from NOAA, National Weather Service.

#### **9.2.2.2 1991**

In 1991, the lower ladder fishway was monitored with a video and upstream trap system from 1 November to 29 December. These systems were similar to those described for 1990, with some exceptions in the video camera orientation and trap system.

To improve viewing conditions, the camera was placed in a waterproof marine plywood box (1m x 1m x 1m) with a plexiglass window that allowed a side view of all fish moving through the chamber. This orientation also allowed identification of the sex of all salmonids. A white background with lined intervals of 5 cm was attached to the side-wall of the chamber, 40 cm from the window. Wire mesh screens (5 cm openings) placed on the sides of the video box forced salmon to swim in front of the viewing window. During periods of video monitoring, the video system was checked and tapes changed twice daily. During these checks, water flow was shut down by a gate in chamber 9A to prevent fish movement, and the lower fishway chambers and video system were cleaned and cleared of debris.

As in 1990, an upstream migrant trap was installed in the lower fishway, but was only operational for part of the in-migration period; generally, during periods of turbidity (1-16 November) and calibration (16-21 November, 9-12 December). The trap was checked three times daily and/or during video tape changes. Prior to release, total lengths (nearest mm) of all salmonids were recorded.

The same information sources were used in this study as were used in 1990 for temperature, flow, precipitation, and barometric pressure data.

### **9.2.3 Dam Video Monitoring**

In 1990, after the boards were removed from Woodbridge Dam, an attempt was made to monitor upstream movement of fish over the first bay opening of the dam with a video system. This system was used to explore the possibility of monitoring salmon movements from the dam instead of the lower ladder. The methods used for this installation were similar to those used in the upper ladder in 1990. A white background was placed upstream of the opening and held in place by concrete anchors. The video camera and lights were suspended out from the top of the dam, 5.5 m from the water surface.

Fish movements were recorded from 15 October - 17 December 1990 but, because of poor water clarity, the distance from the water surface, and sun glare, none of these data were analyzed.

### **9.2.4 Video Review and Data Analysis**

#### **9.2.4.1 1990**

All tapes were reviewed with a Mitsubishi VCR (model HS-U32). The standard review speed was fast forward but, when movement was detected, the tape was replayed at normal speed. Using the 10-cm black lines on the background and advancing the tape frame by frame, the length of each fish was estimated. It was also noted whether salmon were moving upstream or downstream. All salmon less than or equal to 60 cm in length were classified as grilse, and all salmon longer than 60 cm as adults. The sex of salmon could not be identified because the cameras were positioned overhead.

The trap and video system data were analyzed separately. Table 9.1 lists the time categories used in the analysis. The number of chinook salmon captured in the trap was summarized by day and by week. The daily total was calculated by summarizing the total for each time period (combined 0700, 1500, and 2300 hr totals), and weekly totals were calculated by summing the daily totals from Monday through Sunday.

The number of chinook salmon recorded by the video systems also was determined on a daily and weekly basis, and daytime and nighttime movements were analyzed using the video data. Because salmon frequently moved upstream and then downstream, it was not always possible to identify individual salmon; hence, the net upstream movement for each time

category was calculated by subtracting the total number of fish moving downstream from the total number of fish moving upstream. Some fish could not be identified by species from the video data. If an unknown fish was more than 35 cm TL, it was assumed to be a salmon. Identification was further verified by the numbers and lengths of fish caught in the trap.

**Table 9.1.** Time categories used in the analysis of the trap and video data sets during the escapement study on the Mokelumne River, 1990-1991.

SYSTEM	TIME CATEGORY	DEFINITION
TRAP	Daily	Sum of fish observed in trap at daily trap check times
	Weekly	Sum of daily totals for each week
VIDEO	Daily	Sum of fish observed on video tapes from 2300 of the previous day to 2259 of the analysis day
	Weekly	Sum of daily totals for each week, beginning on Sunday at 2300 and ending the next Sunday at 2259
	Day time	Sum of fish observed during daylight hours, starting 1/2 hr before sunrise and ending 1/2 hr after sunset
	Night time	Sum of fish observed during nighttime hours, starting 1/2 hr after sunset and ending 1/2 hr before sunrise

Because of problems with both monitoring systems, at times fish movement information was available from only one of the systems. The combined video and trap data sets were used to investigate spawning migration patterns and to determine the effects of temperature, flow regimes, barometric pressure, and precipitation.

#### 9.2.4.2 1991

All tapes were reviewed using a Panasonic VHS time lapse recorder (model AG-6720A) and Panasonic color monitor (model CT-1331Y). Initially, the tapes were reviewed using the alarm search mode, which located all the alarm signals recorded by the motion detector on tape. However, due to the sensitivity of the motion detector to debris in the water and changes in light conditions, the majority of the alarm signals were not associated with fish movements. As a result, all tapes were subsequently reviewed using the fast forward function. When movement was detected, the tape was replayed at normal speed.

Using the 5 cm black lines on the white background and advancing the tape frame by frame, the total length of each fish was estimated. As in 1990, all salmon less than or equal to 60 cm in length were termed grilse (jacks), and all fish longer than 60 cm were classified as adults. In 1991, it was possible to identify the sex of salmonids.

### 9.3 RESULTS

#### 9.3.1 Comparison of Video and Trapping Systems

##### 9.3.1.1 1990

No salmon were recorded moving upstream by the lower video system from 2 October to 15 October 1990. Similarly, no salmon were caught in the upstream migrant trap during this period.

By late afternoon on 16 October, the lower ladder was operational and salmon could swim through the lower ladder past the dam. On 17 October, salmon were observed for the first time in the riprap below the dam. On the same day, the first salmon were recorded in the lower ladder fish trap. From 15 October - 17 December 1990, 443 in-migrating salmon were recorded on the video system and 431 were caught in the in-migrant trap. Because there were problems with both monitoring systems (Table 9.2), data from each of the systems for three time periods was analyzed and compared. Table 9.3 compares the number of in-migrating salmon in each system for each time period.

In the first comparison period (15-21 October), sediments washing out of Lake Lodi when the boards were removed made the water turbid and obscured fish movement (Table 9.2). However, the fish trap in the lower ladder was working well and 42 salmon were caught while migrating upstream (Table 9.3).

Discrepancies between the video and trap data also were apparent in the second comparison period (22 October - 4 November). More salmon were observed with the video system (n=124) than were captured in the fish trap (n=75) (Table 9.3) because the trap was ripped open several times (Table 9.2) and this allowed salmon to avoid the trap. When the weekly data were compared, 41 more salmon were observed on video tapes than were captured in the fish traps in the week ending 4 November. On 4 November, the trap was repaired and reinforced with a steel mesh frame to collect the debris.

During the third comparison period from 5 November to 14 December, few problems were readily apparent with either system (Table 9.2). Minor power blackouts prevented some video data from being collected, but the trap was working throughout this period. During this period, 309 salmon were caught in the trap and 315 were recorded by the video system, an overall error margin of only 1.9 percent.

**Table 9.2.** Time periods when either the video or trapping system was not fully functional, Mokelumne River escapement study, 1990.

DATE	DOWN TIME		PROBLEMS
	START	END	
Video System			
16 Oct	07:00	23:59	Poor or no counts - turbidity
17 Oct	00:00	23:59	Poor or no counts - turbidity
18 Oct	00:00	23:59	Poor or no counts - turbidity
19 Oct	23:00	07:00	Poor or no counts - turbidity
20 Oct	07:00	14:32	Poor or no counts - turbidity
20 Oct	19:23	19:25	No counts - power failure
22 Oct	15:00	23:00	Poor recording - brief power outage
22 Oct	23:00	07:00	Poor quality - water glare
23 Oct	02:35	02:40	No counts - brief power failure
23 Oct	02:49	02:50	No counts - brief power failure
23 Oct	07:00	15:00	Poor or no counts - turbidity
30 Oct	23:00	07:00	No counts - equipment malfunction
24 Nov	23:00	07:00	No counts - equipment malfunction
26 Nov	05:00	07:00	Poor or no counts - turbidity
27 Nov	11:00	14:30	Poor or no counts - turbidity
09 Dec	15:00	17:42	No counts - power failure
12 Dec	15:00	23:00	Poor or no counts - turbidity
Trap System			
23 Oct	unknown	07:00	Trap screen ripped open
26 Oct	unknown	07:00	Screen down in front of video background
31 Oct	unknown	23:00	Trap screen ripped open
04 Nov	unknown	15:00	Trap screen ripped open

**Table 9.3.** Comparative results of the video and trapping methods for four time periods, Mokelumne River escapement study, 1990.

PERIOD	DATES	TRAP RESULTS				VIDEO RESULTS
		MALES	FEMALES	UNKNOWN	TOTAL	TOTAL
1	15 Oct - 21 Oct	17	22	3	42	4
2	22 Oct - 28 Oct	19	15	5	39	47
	29 Oct - 04 Nov	24	12		36	77
	Total				75	124
3	05 Nov - 11 Nov	30	15		45	48
	12 Nov - 18 Nov	44	26	2	72	75
	19 Nov - 25 Nov	24	10	1	35	42
	26 Nov - 02 Dec	56	24	2	82	83
	03 Dec - 09 Dec	6	3		9	7
	10 Dec - 14 Dec	43	22	1	66	60
	Total				309	315
4	15 Dec - 17 Dec	4	1		5	- -

The fourth time period was after the video system was removed on 14 December. Trapping continued until 17 December; during this time five more salmon were trapped moving upstream.

### 9.3.1.2 1991

Between 2 October and 31 October 1991, a total of six chinook salmon were collected in the upper ladder trap: five adults (2 males, 3 females) and one grilse (female). One female steelhead rainbow trout was also collected during this time period. A total of five salmon were recorded by the upper video system: three adults (sex unknown) and two grilse (sex unknown). Discrepancies in trap and video data are probably due to problems with water turbidity and video system malfunctions during this period.

After the flashboards at Woodbridge Dam were removed on 31 October, the lower ladder trap and video system began functioning on 1 November 1991. Water turbidity continued to hamper video recording efforts, and this system was shut down until conditions improved on 15 November. As a result, only the trap was operational from 1 to 15 November. During this time, a total of 128 chinook salmon and 11 steelhead rainbow trout were collected in the trap.

Once water conditions improved, it was again possible to use the lower video system until the end of the study period (29 December 1991). Problems encountered during videotape recording are listed in Table 9.4. During this time the trap and video systems were operated concurrently in order to compare fish movement recorded by each. Calibration results indicate that either an equal or higher number of fish were observed moving upstream on the video system (Table 9.5). During the entire calibration period, 83 salmon were observed in the traps and 90 salmon were observed on video, an overall margin of error of 7.8 percent. The sex of salmon was more often classified "unknown" on the video system due to the difficulty of identifying sex of fish on the tapes. Further discrepancies in the trap and video data are probably due to errors during review of video tapes and problems with the video system (Table 9.4.).

**Table 9.4.** Time periods when the upper video system was not fully functional, Mokelumne River escapement study, 1991.

DATE	DOWN TIME		PROBLEMS
	START	END	
19 Nov	08:44	10:08	No counts - power failure
28 Nov	14:40	17:04	No counts - tape ran out
03 Dec	21:53	23:45	No counts - tape ran out (many alarms)
04 Dec	08:01	09:30	No counts - tape ran out (many alarms)
12 Dec	08:25	15:29	No counts - equipment malfunction
14 Dec	16:00	17:20	No counts - tape accidentally erased
21 Dec	15:15	23:59	Poor or no counts - condensation on tape
22 Dec	00:00	09:14	Poor or no counts - condensation on tape

**Table 9.5.** Comparative results of the video and trapping methods for three time periods, Mokelumne River escapement study, 1991.

CALIBRATION PERIOD	MALES	FEMALES	UNKNOWN	ADULTS	JACKS	TOTAL
<b>Trap</b>						
15-19 November	34	29	1	54	10	64
20-21 November	5	5	0	9	1	10
9-11 December	6	3	0	7	2	9
<b>Video</b>						
15-19 November	31	27	9	52	15	67
20-21 November	5	2	7	13	1	14
9-11 December	5	4	0	7	2	9

### 9.3.2 Migration Timing and Abundance

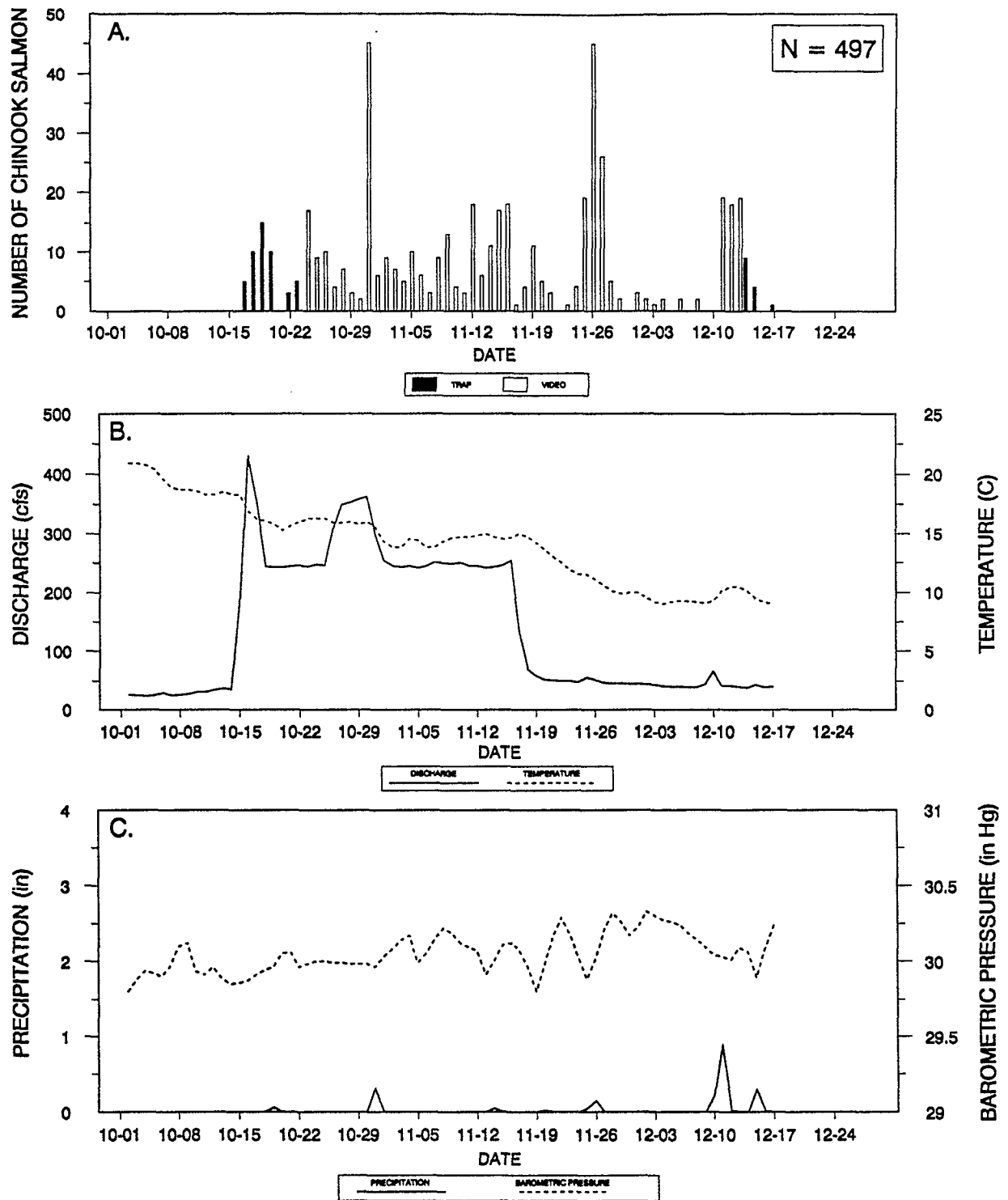
#### 9.3.2.1 1990

When the dam boards were removed on 15 October, many fish from Lake Lodi ( $n > 1000$ ) were trapped in the upstream side of the fish trap including largemouth bass, smallmouth bass, threadfin shad, green sunfish, bluegill, and crappie. Most of the fish were removed from the trap and released downstream, and the rest washed out when the trap was opened.

Video and trap data were used to describe the abundance, timing, movement patterns, run composition, and influencing factors of flow, temperature, and precipitation. Because of problems with the video system on 15-22 October and 14-17 December, salmon counts from the trap were incorporated into the video data during those periods. Using this composite data set, it can be estimated that 497 salmon passed through Woodbridge Dam from 2 October - 17 December. This number reflects the data from the lower ladder video and trap systems, as well as the fish removed from the riprap on 17 October after board removal.

Figure 9-2a summarizes the daily salmon movement patterns at Woodbridge Dam. Fifty percent of the salmon migrated before 18 November. Peak salmon migrations occurred in late October and late November: 45 salmon were recorded on both 31 October and 26 November.

Flow regimes, water temperature (recorded downstream of Woodbridge Dam), and total rainfall and barometric pressure during the monitoring period are shown in Figures 9-2b and 9-2c. Immediately after flashboard removal on 15 October, mean daily flow increased from 35 cfs to 181 cfs (Figure 9-2b). Peak flow was observed at 431 cfs on 16 October. Flows remained above 200 cfs until 17 November, when mean daily flow fell below 75 cfs. Water temperature decreased from 21.3° C prior to board removal (1 October) to a low of 9.0° C on 17 December (Figure 9-2b).



**Figure 9-2.** A) Daily salmon counts collected at Woodbridge Dam during the 1990 escapement study on the Mokelumne River. Data is from the combined results of the video and trap monitoring systems (inclusive of the salmon removed from the riprap). B) Mean daily flow (USGS Station #11325500) and mean water temperature (EBMUD datapod at Woodbridge Golf Course) measured downstream of Woodbridge Dam during the escapement period. C) Total rainfall (Lodi Fire Department) and average barometric pressure (Sacramento Executive Airport) recorded during the escapement period.

Because peak spawning movements seem to be more closely associated with precipitation events (periods of rainfall) rather than changes in attraction flows (Figure 9-2c), intervention analysis (Box and Tiao 1975) was conducted to determine whether daily salmon movement abruptly increased or decreased during such events. The analysis identifies changes as pulses (short increase or decrease followed by return to earlier values) or as steps (abrupt increase or decrease with equilibration at a new level). In 1990, two significantly positive pulse effects were found on 31 October and 26 November; precipitation also occurred on both days (Figures 9-2a and 9-2c). The results indicate that precipitation events appeared to stimulate short-term increases in salmon movement past Woodbridge Dam.

The influence of precipitation on the overall size of the run did not appear to be significant. During the 1990 migration season, 38 percent of all salmon passed the dam during precipitation events, while 62 percent migrated during periods with no precipitation. Several precipitation events (19 October, 10 December and 15 December) did not appear to be associated with any pulse in migration.

Day/night movement patterns were analyzed to determine if any diel periodicity occurs during in-migration (Figure 9-3a). Of the 443 salmon observed on video tape, 57 percent moved upstream during the day and 43 percent migrated at night.

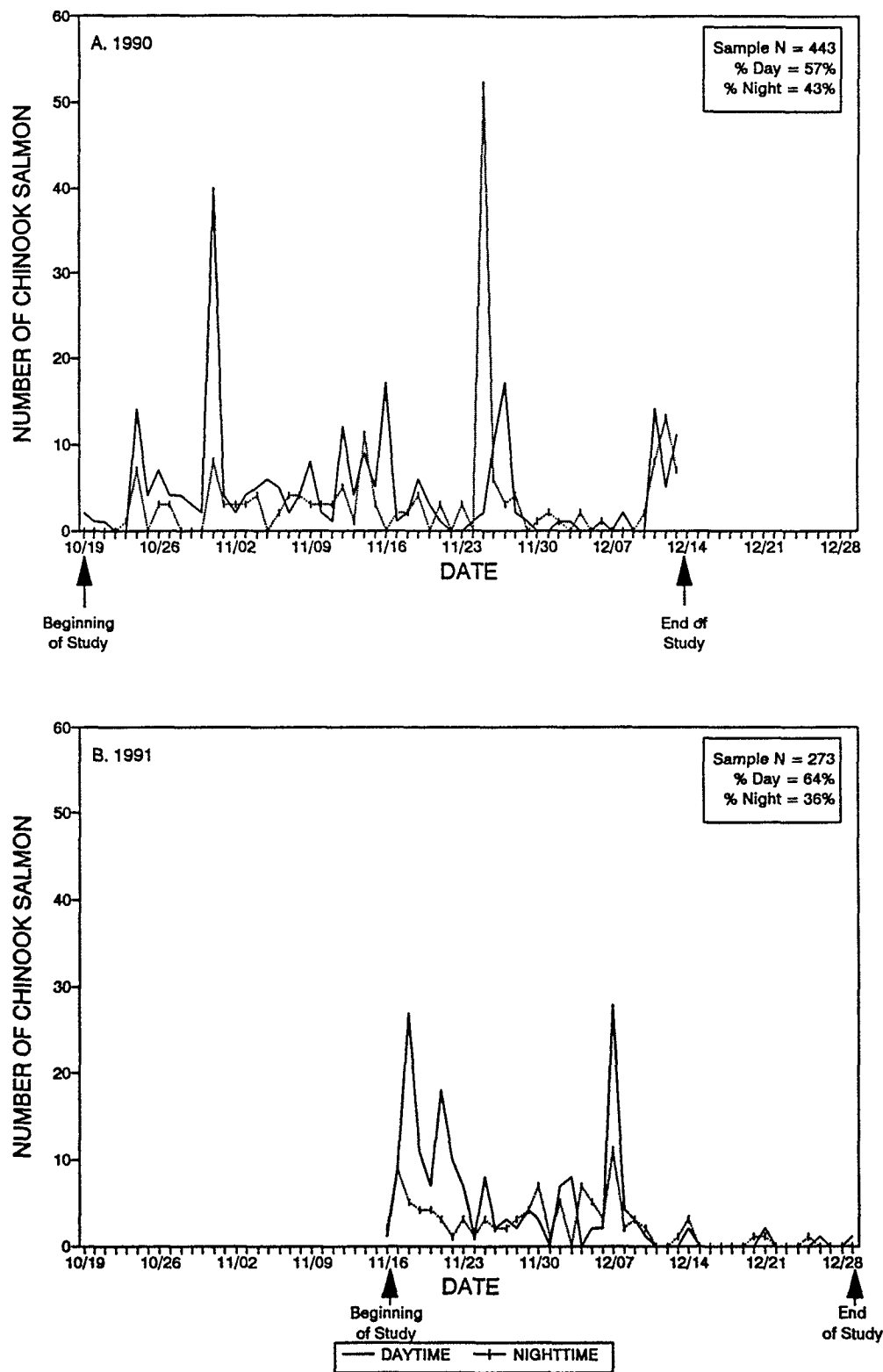
Steelhead rainbow trout were the only other anadromous species observed moving upstream during the study period. In all, only four steelhead rainbow trout were trapped: two on 22 October, one on 5 November, and one on 12 November; however, more steelhead may have migrated after monitoring was finished on 14 December.

#### 9.3.2.2 1991

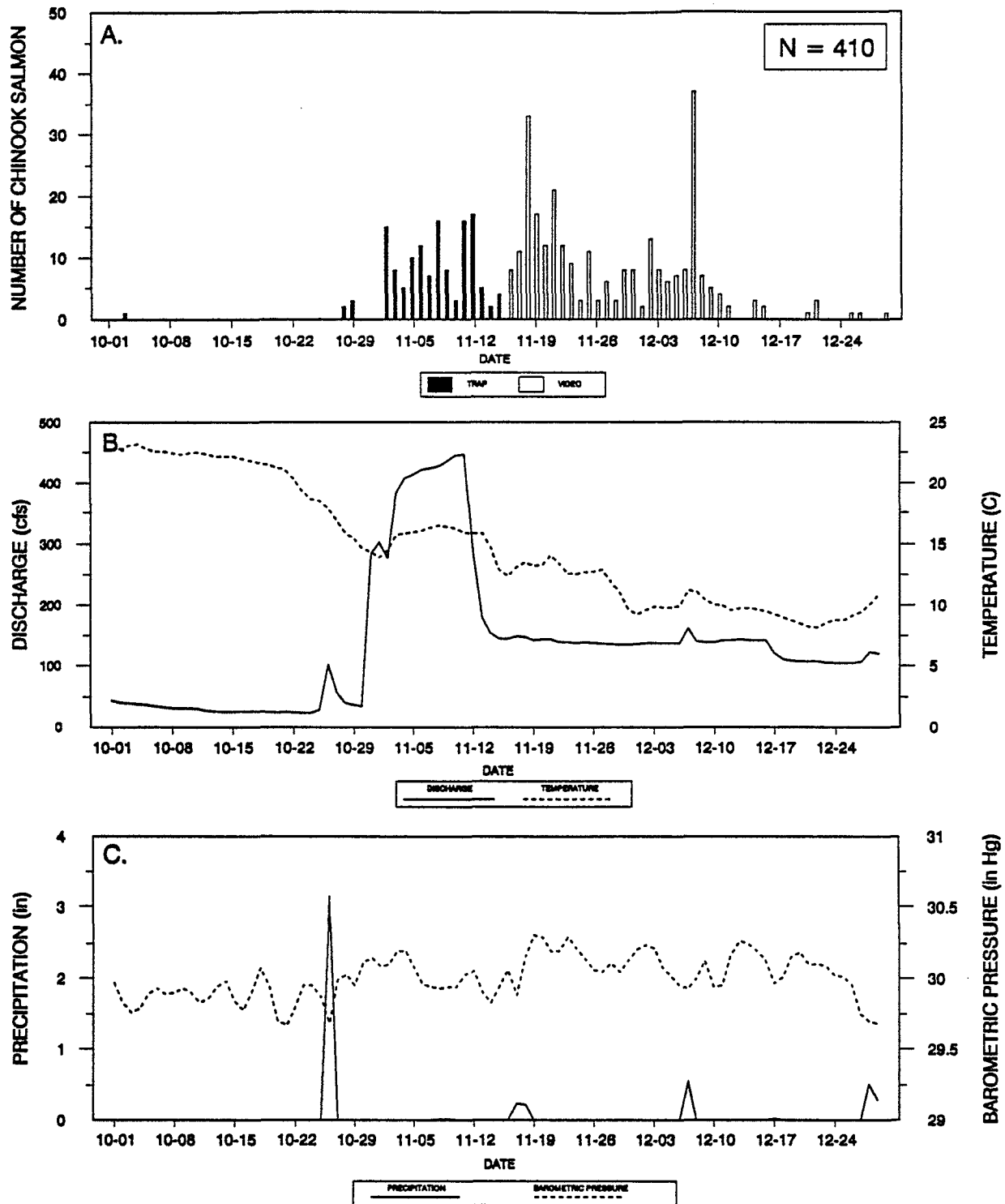
As in 1990, video and trap data were combined to describe the abundance, timing, movement patterns, and run composition of the 1991 escapement. Data from the upper trap were used from 1 through 31 October, from the lower trap from 1 through 15 November and from the lower video system from 16 November through 29 December. Using these data, it is estimated that 410 chinook salmon migrated past Woodbridge Dam during the escapement period in 1991. Twenty-two salmon less than 40 cm total length were also counted but are not included in this total.

Figure 9-4a summarizes the daily salmon movement patterns at Woodbridge Dam. Seventy-one percent of salmon migrated in November, although a significant daily movement also occurred in December. Peak daily counts were observed on 18 November (33 salmon) and on 7 December (37 salmon).

Flow regimes, water temperature (recorded downstream of Woodbridge Dam), and total rainfall and barometric pressure during the monitoring period are shown in Figures 9-4b and 9-4c. Immediately following removal of the flashboards at the dam on 30 October, the mean daily flow increased from 35 cfs to 284 cfs. Maximum flow was observed at 447 cfs on 11 November. After 12 November, flows decreased but remained above 100 cfs throughout the remainder of study period. Water temperatures ranged from a high of 23.2° C (4 October) to a low of 8.2° C (22 December).



**Figure 9-3.** Number of chinook salmon migrating during the day and night as observed by the video system monitoring escapement in the Mokelumne River, 1990-1991.



**Figure 9-4.** A) Daily salmon counts collected at Woodbridge Dam during the 1991 escapement study on the Mokelumne River. Data is from the combined results of the video and trap monitoring systems.  
 B) Mean daily flow (USGS Station #11325500) and mean water temperature (EBMUD datapod at Woodbridge Golf Course) measured downstream of Woodbridge Dam during the escapement period.  
 C) Total rainfall (Lodi Fire Department) and average barometric pressure (Sacramento Executive Airport) recorded during the escapement period.

As in 1990, peaks in migration appear associated with precipitation events. Using intervention analysis, two significantly positive pulse effects were identified on 18 November and 7 December, and precipitation occurred on both those days (Figures 9-4a and 9-4c). As in 1990, the results indicated that precipitation events appeared to stimulate short-term increases in salmon movement past Woodbridge Dam.

The influence of precipitation on the overall size of the run did not appear to be significant. During the 1991 migration season, 30 percent of all salmon passed the dam during precipitation events, while 70 percent migrated during periods with no precipitation. Two other precipitation events (26 October and 31 December) did not appear to be associated with any pulse in migration.

Day/night movement patterns were analyzed from the video tapes to determine whether any diel periodicity occurs during in-migration (Figure 9-3b). Of the salmon observed on the video tapes from 16 November through 29 December, 64 percent moved upstream during the day and 36 percent migrated at night.

### **9.3.3 Run Composition**

#### **9.3.3.1 1990**

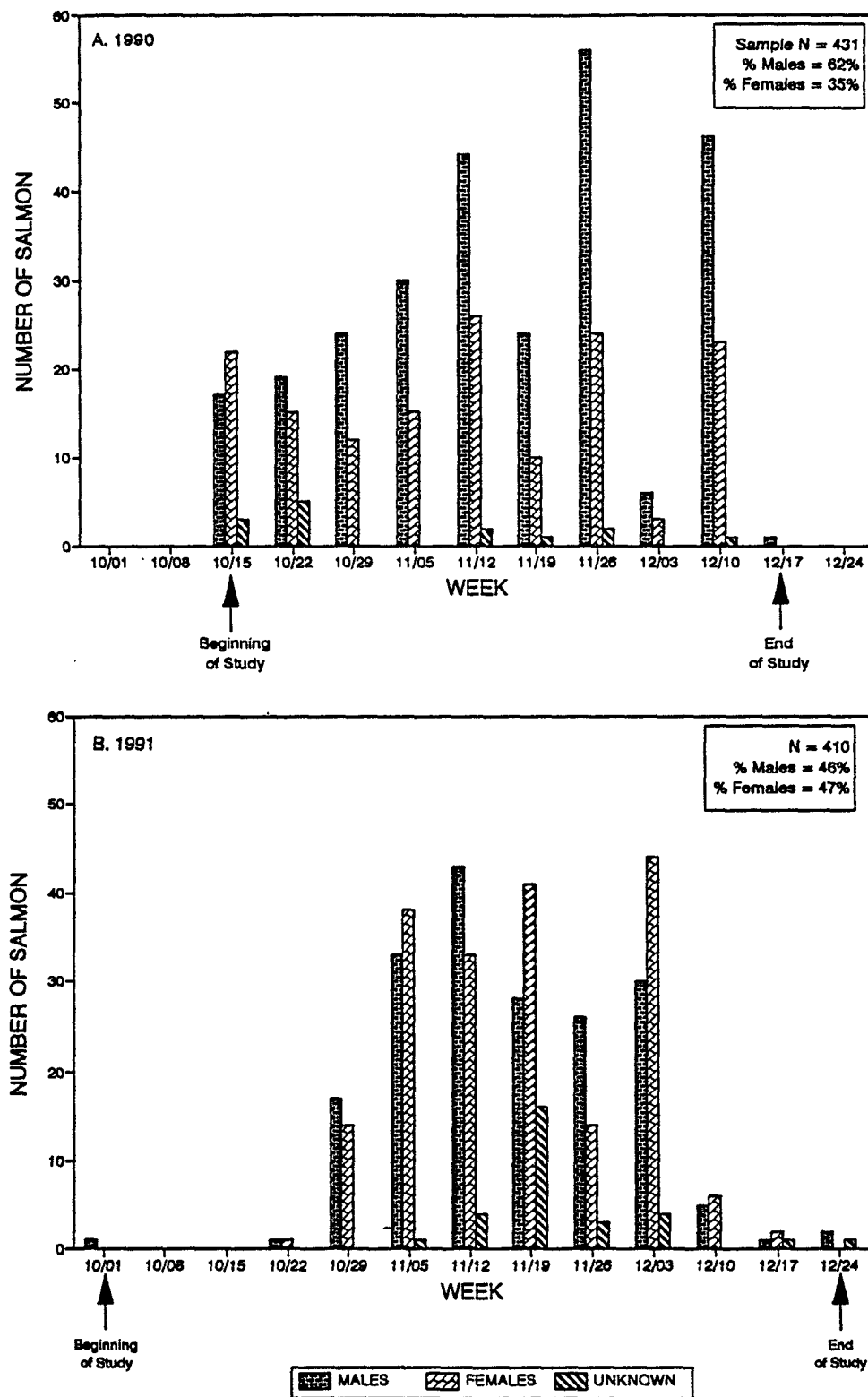
In 1990, salmon trapped in the lower fishway were identified as to sex in order to determine the sex ratio of the in-migrating population. Of the 431 salmon trapped and examined, 62 percent were males and 35 percent females, while the sex was not determined for 3 percent. Applying this ratio to our overall population estimate ( $n=497$ ), it is estimated that 306 males and 176 females passed through Woodbridge Dam in 1990. The weekly movement patterns of males and females in the trap are shown in Figure 9-5a.

The percentage of adults and grilse in the migrating population was determined by analyzing the length data derived from the video tape review. Of the 443 salmon examined in the video tapes, 69 percent were adults and 31 percent were grilse. Applying this ratio to the overall migrating population ( $n=497$ ), it is estimated that 344 salmon passing through the dam were adults and 153 were grilse. No distinct pattern was apparent for grilse movement (Figure 9-6a). Peak movements of adult salmon occurred during three periods: late October/early November, mid-November, and late November.

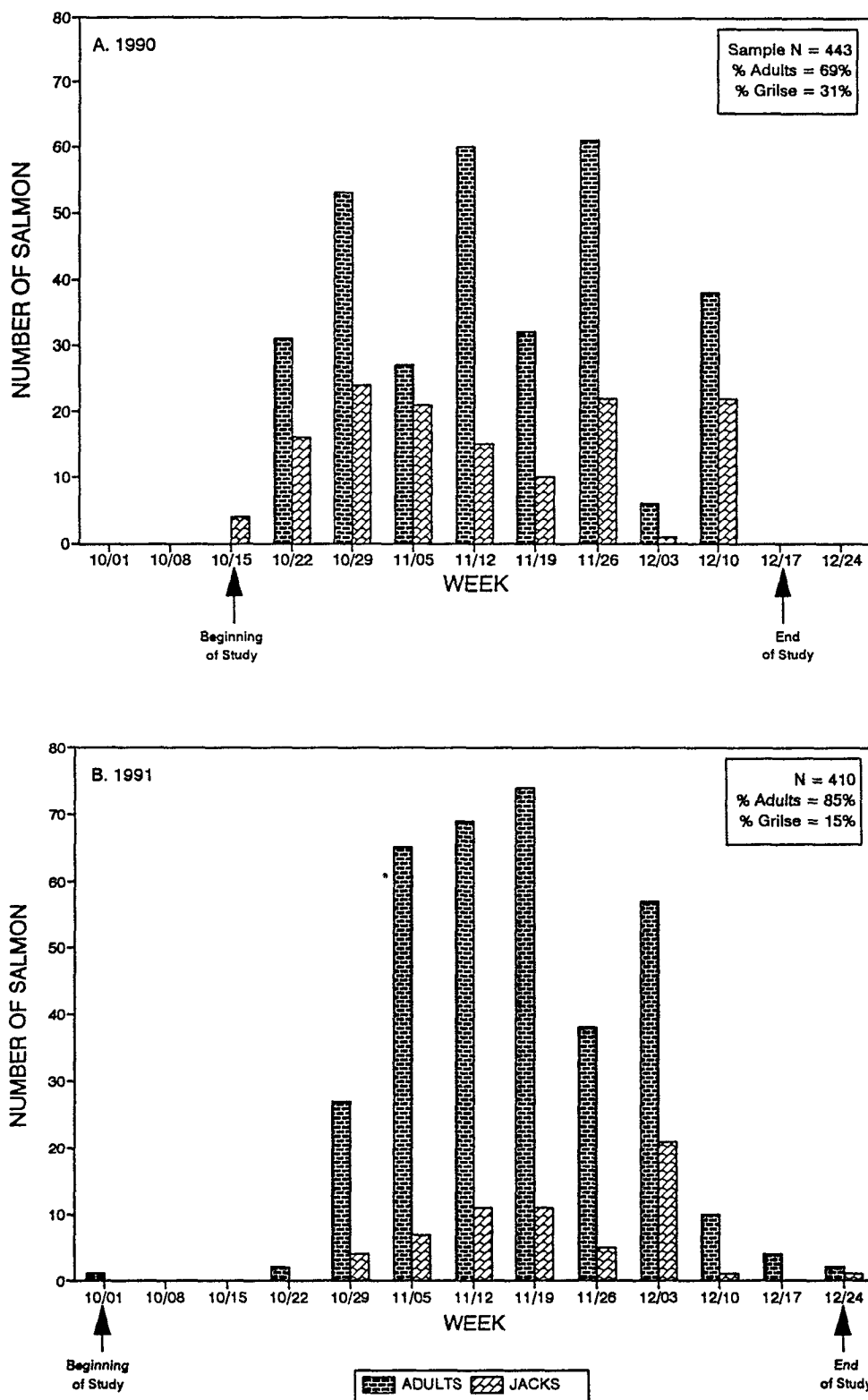
The length frequency distribution of the migrating salmon observed on the video tapes is shown in Figure 9-7a. Total lengths of salmon ranged from 35-135 cm and averaged 76.3 cm ( $SD = 17.6$  cm). No clear division of length frequencies of adult and grilse populations was apparent.

#### **9.3.3.2 1991**

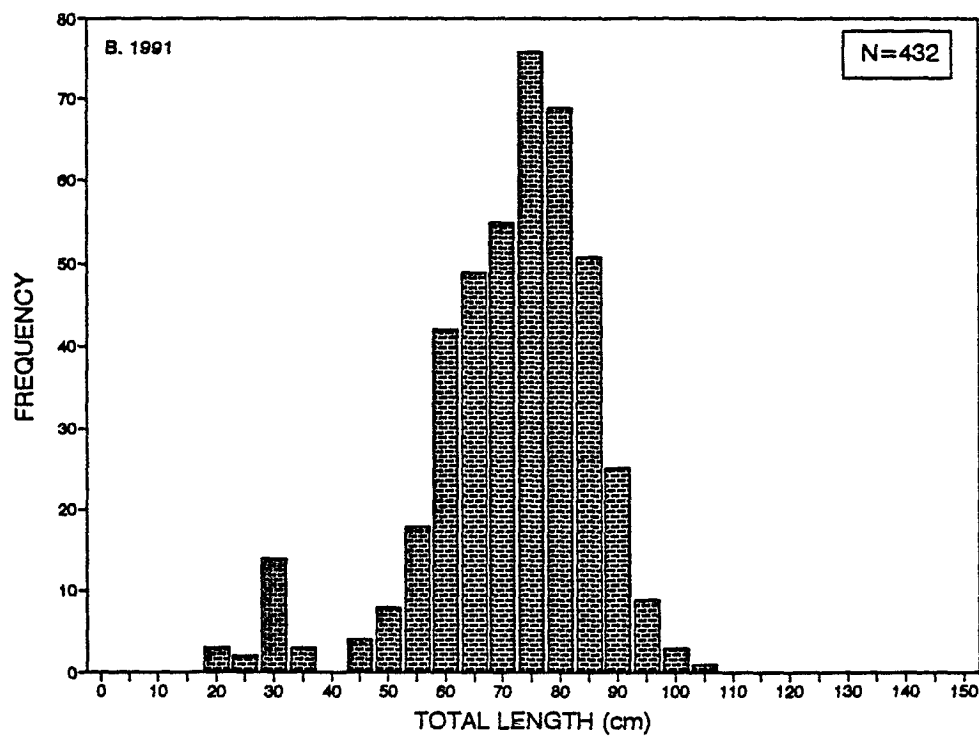
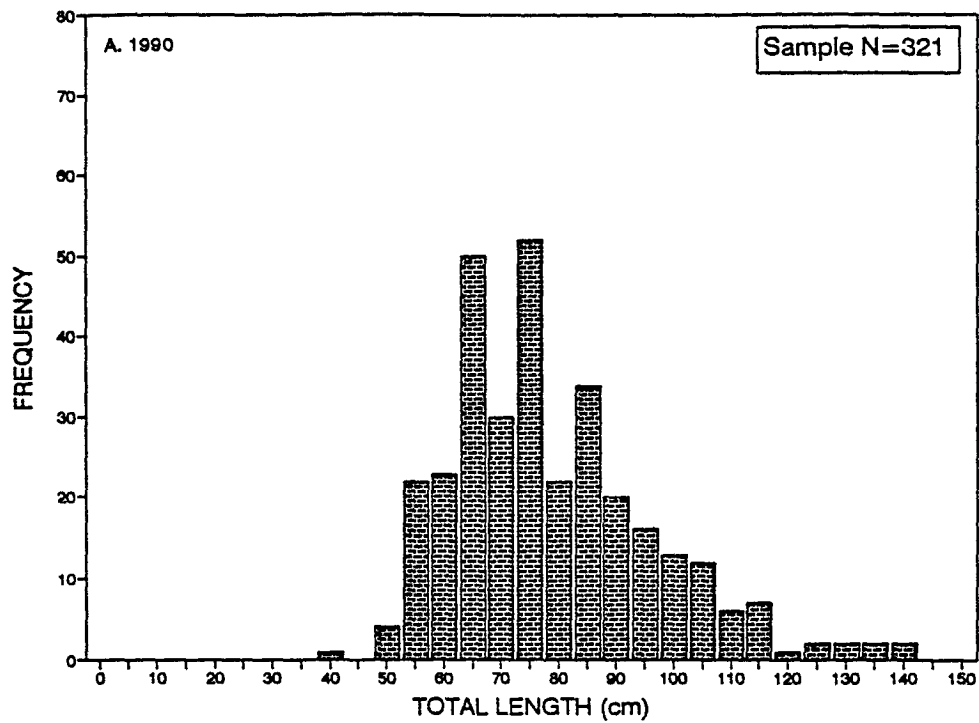
In 1991, all salmon trapped and/or observed on video tape were identified as to sex in order to determine the sex ratio of the in-migrating population. A higher number of females were



**Figure 9-5.** Number of male and female salmon observed at Woodbridge Dam during escapement studies on the Mokelumne River, 1990 - 1991.



**Figure 9-6.** Number of adult salmon (>60 cm) and grise salmon (<60 cm) observed at Woodbridge Dam during escapement studies on the Mokelumne River, 1990 - 1991.



**Figure 9-7.** Length frequency distribution of chinook salmon observed at Woodbridge Dam during escapement studies on the Mokelumne River, 1990 - 1991.

observed in 1991 compared to 1990. Of the 410 fish (>40 cm TL) observed, 46 percent (N=187) were male, 47 percent (N=193) were female, and 7 percent (N=30) could not be confidently identified. The weekly movement patterns of males and females in the trap are shown in Figure 9-5b.

The percentage of adults and grilse (jacks) in the migrating population was determined by analyzing the length data derived from all data sets. More adults than grilse were observed in 1991. Of the 410 salmon (>40 cm), 85 percent (N=349) were adults and 15 percent (N=61) were grilse. No distinct pattern was apparent for adult and grilse movement (Figure 9-6b).

In 1991, the length frequency of fish measured during trapping was compared to that of the estimated lengths of fish on the video. These two distributions were found to be similar (chi-square goodness of fit,  $X^2 = 26.67$ ,  $p < 0.05$ ).

The length frequency distribution of the migrating salmon is shown in Figure 9-7b. Total lengths ranged from 18-107 cm. The average size of salmon (>40 cm TL) was 76.1 cm (SD = 11.0), which did not significantly differ from the 1990 average (ANOVA,  $F=0.02$ ,  $p > 0.05$ ). No clear division of length frequencies of adult and grilse populations was apparent.